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INPUT DATA, ARMS MODEL SIMULATION OF THE OH-58A IN AN ARMY TACTICAL ENVIRONMENT

COBRO Corporation
10750 Columbia Pike
Silver Spring, Maryland 20901

May 1977

Approved for public release;
distribution unlimited.

Prepared for

EUSTIS DIRECTORATE
U. S. ARMY AIR MOBILITY RESEARCH AND DEVELOPMENT LABORATORY
Fort Eustis, Va. 23604

DRAFT DIRECTORATE POSITION STATEMENT

The OH-58A helicopter has been validated in the Aircraft Reliability and Maintainability Simulation (ARMS) model. Manpower, ground support equipment, and scheduled and unscheduled maintenance have been modeled for the AVUM and AVIM maintenance levels. Simulation experiments were conducted to determine the model's sensitivity, credibility, and sufficiency. Changes in operational availability resulting from changes in TBO policy, major inspection policies, failure rates, supply rates, and utilization rates were consistent with actual data from the field.

The conclusions contained herein are concurred in by this Directorate.

The technical monitors for this contract were Mr. Howard M. Bratt, Mr. Garry R. Newport, and Mr. Robert A. Hall, Military Operations Technology Division, Eustis Directorate.

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This report presents the results of the engineering process to develop the input data and to simulate the OH-58A in an Army tactical environment, using the Aircraft Reliability and Maintainability Simulation (ARMS) model. The flexibility and degree of detail found in the model provides the Army with a tool for rapid and reliable response to complex RAM, logistics, and survivability/vulnerability-related questions and their inpact upon the system effectiveness of the OH-58A.

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PREFACE

This report presents the results of the engineering process to develop the input data and to simulate the OH-58A operating in an Army tactical environment, using the Aircraft Reliability and Maintainability Simulation (ARMS) model. The work was conducted under Contract DAAJ02-77-C-0017 with the Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory (USAAMRDL), Fort Eustis, Virginia.

Mr. Howard Bratt, Reliability and Maintainability Modeling and Analysis Branch, Military Operations Technology Division, USAAMRDL, served as the Contracting Officer's Technical Representative for the program.

The project engineer for COBRO Corporation was Mr. James Marsh. Significant contributions were made by Mr. Willis Hawkins of the New Equipment Training Branch, U.S. Army Aviation Systems Command, St. Louis, Missouri.

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1.0 INTRODUCTION AND SCOPE

The ARMS model has been designed to evaluate the effectiveness of an entire system while that system is being used to accomplish a tactical military task under combat threats. It is a complex tool, requiring substantial skill in application and interpretation of the results. The model's value is functionally dependent upon the level of detail used in defining the data elements and on the reliability of the data sources upon which the structure is based.

It is important to provide a logical procedure for satisfying the data requirements of the model. All available operational feedback sources were investigated as to their reliability and availability. Applicable documents regarding TO&E structures, maintenance concepts, operational assessment reports, and mission descriptions were assembled. This data, coupled with technical assistance from the user level, provided the basis from which COBRO developed a detailed simulation of the OH-58A operating in an Army tactical environment.

This validated model will provide the Army with the capability and flexibility to investigate a large range of Reliability, Availability, Maintainability/Logistics analyses of the current OH-58A and of any future OH-58A modifications.

2.0 GENERAL INFORMATION

The length of the simulation period is 1 month (28 days), comprised of 2 weeks of regular or normal operation, 1 week of surge conditions, and concluding with 1 week of normal operation.

A total of 20 aircraft in two configurations are simulated. Configuration A is the basic OH-58A. Configuration B has the M27E1 (7.62 Minigun) armament subsystem installed. Reconfiguration time between Configurations A and B is provided in the input.

The maximum number of deferred maintenance actions allowed before downing an aircraft during regular operations is four. This value doubles during the surge period.

Attrition replacement time for lost aircraft is 24 hours.

Aircraft are initialized between 25 and 300 flight hours and between 0 and 730 calendar days at equal intervals.

Launch windows for regularly scheduled and random missions were constructed by mission types. Mission numbers four and six have launch windows of one hour for both scheduled and random missions. All other missions simulated in the model have launch windows of two hours for both scheduled and random mission calls.

No standby or alert aircraft are simulated in the model.

3.0 ELEMENT DATA

The elements defined in the model represent the significant maintenance items on the OH-58A. Not Otherwise Classified (NOC) elements were presented as a category to summate the maintenance on the less significant items. A total of 173 elements in 17 distinct subsystems were used to define the OH-58A. The maintenance rates represent operational values and include all maintenance performed on the item. The probability of before-flight and inflight mission aborts was derived for each required item. These values were obtained mainly from the Navy Maintenance Material Management (3-M) data on the TH-57A, which consisted of a base of 156 aircraft with a total of 137,143 flight hours. The TH-57A and OH-58A were noted by respective changes in failure rates. Data for the avionics system was extracted from The Army Maintenance Management System (TAMMS) reporting on the OH-58A for the period 1 July 1970 through 30 June 1972 which consisted of a base of 562,020 flight hours.

The basis for the determination of the failure rate data for the M27E1 Armament System was 2 years (1971-1972) of test results provided by the U.S. Army Armament Command (ARMCOM). The failure data provided by ARMCOM was a value of 8009 Mean Rounds Between Failures (MRBF). Since this value was not compatible with the required input format in the ARMS Model, it was modified to failures per flight-hour, based on the following procedure:

(1) Only Configuration B aircraft are equipped with the M27E1 Armament System.

(2) Average flight hours per mission for Configuration B aircraft is 2.57 hours.

(3) COBRO assumed an average of 1000 rounds of ammunition are expended per mission. Therefore the failures per mission is equal to:

$$\frac{1000 \text{ rounds/mission}}{8009 \text{ rounds/failure}} = .124860 \text{ failures/mission}$$

(4) The failure rate would then be:

$$\frac{.124860 \text{ failures/mission}}{2.57 \text{ flight-hour/mission}} = .048583 \text{ failures/flight-hour}$$

Based on the following rate, the Mean Time Between Failures (MTBF) for the M27E1 system would be 20.58 flight-hours on Configuration B missions.

A detailed analysis was performed by COBRO to determine the flight safety significant (Red X) items, their corresponding rate of occurrence, and the resulting consequences of the inflight failure. Data reported by the U.S. Army Agency for Aviation Safety (USAAAVS) on the OH-58A was used. This data base consisted of 2 years of reporting (1 July 1973 - 30 June 1975) and contained 851 mishaps in 467,424 flight-hours. These safety significant elements are defined in the model and represent the material causes identified in the USAAAVS data. The respective USAAAVS mishap categories (Total Loss, Major Accident, Minor Accident, Incident, Forced Landing, and Precautionary Landing) were integrated with the ARMS model consequences so that equivalent definitions would apply.

The probabilities of failure discovery were developed through engineering judgement. The rationale used was that most actions would be discovered during the daily inspection if not discovered at the time of occurrence. Effort was also applied to the other scheduled maintenance events and probabilities were assigned to reflect undetected maintenance at later events.

4.0 AVUM AND AVIM MANPOWER AND GSE REQUIREMENTS

Detailed MOS structures and the quantity required of each type of MOS for both the Aviation Unit Maintenance (AVUM) level and the Aviation Intermediate Maintenance (AVIM) level are presented in Tables 1 and 2, respectively. Development of the MOS structures and the quantity required of each MOS were based upon an analysis of the maintenance requirements of the OH-58A by COBRO with significant assistance provided by the New Equipment Training Branch at the U.S. Army Aviation Systems Command.

Major Ground Support Equipment (GSE) required at the AVUM and AVIM levels is presented in Tables 3 and 4, respectively. No data is provided for GSE failures or repair in the model, but delay times are furnished to simulate acquisition, setup, and return-to-storage times for each piece of equipment at the AVUM level. The GSE at the

TABLE 1. MANPOWER REQUIRED AT AN ARMY AVIATION UNIT MAINTENANCE (AVUM) LEVEL FOR SUPPORTING 20 OH-58A AIRCRAFT

MOS NO.	TITLE	QUANTITY OF EACH
67V20	Crew Chief	20
67W	Tech Inspector	2
68B	Engine Repairman	1
68G	Airframe Repairman	1
35K	Avionics Repairman	1
68F	Electronics Repairman	1
68D	Powertrain Repairman	2
68M	Weapon Systems Repairman	1
67A	Service Crewman	2

TABLE 2. MANPOWER REQUIRED AT AN ARMY AVIATION INTERMEDIATE MAINTENANCE (AVIM) LEVEL FOR SUPPORTING 20 OH-58A AIRCRAFT

MOS NO.	TITLE	QUANTITY OF EACH
67W	Tech Inspector	1
68B	Engine Repairman	1
68G	Airframe Repairman	1
35L	Avionics Repairman	1
68F	Electronics Repairman	1
68D	Powertrain Repairman	1
68M	Weapon Systems Repairman	1

TABLE 3. MAJOR GSE REQUIRED AT AN ARMY AVIATION UNIT MAINTENANCE (AVUM) LEVEL FOR SUPPORTING 20 OH-58A AIRCRAFT

GSE	QUANTITY REQUIRED
Hydraulic Service Unit	1
Maintenance Platform	6
Hoist	2
Hydraulic Tripod Jack	4
Mobile Power Unit	1
Wheeled Tractor	1
Fuel Truck	2
Transportation Trailer	2

TABLE 4. MAJOR GSE REQUIRED AT AN ARMY AVIATION INTERMEDIATE MAINTENANCE (AVIM) LEVEL FOR SUPPORTING 20 OH-58A AIRCRAFT

GSE	QUANTITY REQUIRED
Sheet Metal Shop Set	1
Powerplant Shop Set	1
Propeller-Rotor Shop Set	1
Avionics Shop Set	1
Electronics Shop Set	1
Hydraulics Shop Set	1

AVUM level was integrated into functional packages as required to best simulate its utilization during maintenance. The development of the GSE data was based upon the same effort discussed in the previous paragraph.

5.0 UNSCHEDULED MAINTENANCE

The elapsed maintenance times for on-aircraft actions represent actual lognormal task time distributions as reported in the Navy 3-M system for the TH-57A. Engineering judgement supplemented available task time data for the avionics and armament subsystems. The ARMS model Lognormal distribution function was used for all remove-and-replace, and repair-in-place actions.

Probabilities of remove-and-replace, incorrect repair, and incorrect remove-and-replace were based on actual historical data on the TH-57A. The probabilities of incorrect on-aircraft repair and incorrect remove-and-replace actions were determined by a detailed analysis by COBRO of the maintenance generated by the following malfunction codes:

(a) Adjustment/Alignment Improper
(b) Improper/Faulty Maintenance
(c) Improper Handling
(d) Improperly Positioned or Selected
(e) Tension Incorrect

Since no reported data was available for incorrect diagnosis, these probabilities were based upon engineering judgement. Factors such as functions performed by the item as well as the degree of difficulty in troubleshooting were included in the decision process.

The types of MOS used in the performance of an on-aircraft task were based upon the definition of the duties performed by each type of MOS, coupled with the maintenance action requirement. The crew chief performs a majority of the AVUM maintenance and assists the more highly trained personnel in removal and installation of major components such as engine, transmission, rotor hubs, and blades. On-aircraft maintenance actions that are authorized to be performed by AVIM personnel are presented as required in the model. The revised Maintenance Allocation Chart for the three-level structure, as noted in TM55-1520-228-23 (Reference 1), was used as the basis for these decisions.

[1]Technical Manual 55-1520-228-23, ORGANIZATIONAL MAINTENANCE MANUAL: ARMY MODEL OH-58A HELICOPTER, Department of the Army, Washington, D.C., 1976.

The GSE utilization was based upon engineering judgement of the types of equipment required in the performance of each task.

Administration and supply delay times were not included in the model. Analyses of the Navy 3-M reporting system indicate that administrative and supply delay times are included as part of the total elapsed maintenance time.

In compliance with the requirements stipulated in TM55-1500-328-25 (Reference 2), Section III, "Maintenance Test Flights and Maintenance Operational Checks," a determination of the necessity of test flights was made. The probabilities of initiating test flights in the model upon completion of unscheduled remove-and-replace and repair-in-place actions are as follows.

Removal and Replacement of:	Probability (%) of Test Flight Being Generated
(1) Engine	99
(2) Transmission	99
(3) Tail Rotor Gearbox	99
(4) T/R Driveshaft	99
(5) Tailboom	99
(6) Freewheeling Assembly	99
(7) T/R Hub and Blade	99
(8) Main Rotor Hub and Blade	99
(9) Hydraulic Servo Actuators	99
(10) Swashplate	99
(11) Mast	99
(12) Fuel Control	99
(13) Governor	99
(14) Oil Cooler	99
(15) Linear Actuator	99
Repair on Aircraft of:	
(1) M/R Blade	99
(2) T/R Blade	99
(3) Linear Actuator	99
(4) Fuel Control	99
(5) Governor	99
(6) Significant Fixed Flight Controls	25

Test flights will also be performed after each Significant Maintenance Action (SMA) and after the 300-hour periodic inspection.

[2] Technical Manual 55-1500-328-25, AERONAUTICAL EQUIPMENT MAINTENANCE MANAGEMENT POLICIES AND PROCEDURES, Department of the Army, Washington, D.C., July 1972.

The probability of spare parts being in stock was assumed to be 100 percent for both regular and surge periods in the simulation. COBRO did develop an inventory restock time distribution for future analyses that may assume lower probabilities of spare parts being in stock. These types of analyses would generate Not Operational Ready Supply (NORS) values based on the additional downtime waiting for parts.

A parallel maintenance matrix simulating the probabilities of multiple maintenance actions on like and different systems being performed at the same time was developed by COBRO. This matrix was based on engineering judgement and includes probabilities of parallel maintenance on all systems defined.

6.0 OFF-EQUIPMENT REPAIR

All items requiring repair at either the AVIM or depot levels are identified in the model. Task times for the AVIM repair were extracted in part from the TAMMS reporting on the OH-58A, supplemented by engineering judgement as required. Only the mean values were used for these task times. Also, no maintenance time data was developed for items requiring repair at the depot level.

Based upon the revised three-level OH-58A Maintenance Allocation Chart in Reference 1, the probabilities of repair at the AVIM and depot levels were made.

The probabilities of scrap, incorrect repair, and repeat repair at the intermediate level were developed based on engineering judgement. Factors such as item complexity, manpower skill level to repair, and repair cost versus new cost were used in estimation of these values.

The manpower designated in the off-equipment repair actions represent the utilization of AVIM personnel based on the definition of duties performed by each type of MOS. This input along with the GSE utilization was developed through an engineering decision process of all factors involved.

7.0 SIGNIFICANT MAINTENANCE ACTIONS (SMA)

SMA were developed to simulate the RAM effects of the following conditional events:

SMA No. 10 - Hard Landing (No Significant Damage)

Hard landing is defined as any accident or incident in which ground impact of the helicopter causes severe pitching of the main rotor, allowing hard contact of rotor hubs with the mast, or results in noticeable yielding or cracking of the fuselage pylon support structure or the landing gear. The SMA simulated in the model assumes that no significant major damage was generated to the aircraft by the hard landing. The downtime associated with this event was attributed to the required ground inspections and operational checks before classifying the aircraft on operational status.

Average Elapsed Maintenance Time (EMT) associated with hard landing	- 2.5 hr
Average number of men on task	- 1.4
Duration of test flight required after all inspections	- 0.4 hr
Total downtime associated with event	- 2.9 hr

SMA No. 11 - Main Rotor Sudden Stoppage (Major Damage)

If main rotor sudden stoppage occurs, the following components are to be replaced and returned to depot maintenance for evaluation:

(1) M/R blades and attachments
(2) M/R hub
(3) Mast
(4) Swashplate
(5) Control tubes
(6) Control rods (rotor-to-swashplate levers)
(7) Transmission

Detailed inspections of the engine section and T/R drive system are also to be performed to detect obvious damage. A test flight is required after all maintenance is accomplished.

Average EMT associated with M/R sudden stoppage	- 21.6 hr
Average number of men working	- 2.0
Duration of test flight required after all inspections	- 0.4 hr
Total downtime associated with event	- 22.0 hr

SMA No. 12 - Main Rotor Overspeed (No Significant Damage)

A main rotor overspeed condition occurs if the rotor has been operated in excess of 390 RPM. Both M/R and T/R blades are visually inspected for deformation or damage. Also, inspections are performed on the T/R driveshaft bearing hanger brackets and oil cooler blower fan.

Average EMT associated with M/R overspeed	-	0.8 hr
Average number of men working	-	1.1
Duration of test flight required after all inspections	-	0.4 hr
Total downtime associated with event	-	1.2 hr

8.0 SCHEDULED MAINTENANCE EVENTS

The scheduled maintenance events defined for the OH-58A were developed based upon the current inspection requirements in Reference 1. Table 5 presents a breakdown of the flight-hour and calendar events, frequency of occurrence, and the man-hours to perform each scheduled event. In addition to these events, a daily inspection will be performed before the first flight of the day, and will be accomplished in .9 hour with one man working.

9.0 TIME BETWEEN OVERHAUL (TBO) COMPONENTS

In accordance with the overhaul requirements identified in Reference 1, Section IV, the following TBO items and their respective overhaul intervals were identified for the OH-58A in the model:

M/R Hub Assembly	-	1200 hours
Transmission Assembly	-	2000 hours
Engine (T63-A-700)	-	750 hours
T/R Gearbox Assembly	-	1500 hours

The simulation assumes that the TBO removed components are sent to the depot repair level for overhaul.

10.0 MANPOWER SHIFT SCHEDULE AND WORKING HOURS

A maintenance manpower shift schedule was developed to depict tactical Army field operations in a combat environment. During regular or peacetime activities, the AVUM and AVIM personnel were available from 0600 to 1600 hours, 7 days a week. No second shift was available. During surge (simulated combat) periods, the AVUM and AVIM personnel were available 24 hours each day.

TABLE 5. OH-58A SCHEDULED INSPECTION EVENTS

Flight-Hour Inspections

Flight-Hour Frequency	Event	Man-Hours to Perform
12.5	Obtain engine oil sample (Spectrometric Oil Analysis Program (SOAP))	0.2
25	(1) Check and service nickel cadmium battery	0.3
	(2) Check voltage regulator setting	0.2
	(3) Obtain transmission oil sample (SOAP)	0.2
	(4) Obtain T/R gearbox oil sample (SOAP)	0.2
	(5) Obtain hydraulic reservoir oil sample (SOAP)	0.2
	Total:	1.1
50	Inspect T/R drive system	0.3
100	Remove battery for charging at AVIM level (Float battery issued)	1.0
150	(1) Remove transmission oil cooler and inspect radiator for FOD	1.5
	(2) Remove, inspect and clean double check valve	0.5
	(3) Perform deceleration check on engine	0.5
	(4) Change engine oil	0.3
	(5) Change freewheeling unit oil	0.2
	(6) Inspect and clean engine oil filter	0.2
	(7) Remove, inspect and clean all chip plugs (5)	0.5
	(8) Change transmission oil and filter	0.4
	(9) Grease T/R and M/R pitch change linkages and swashplates	0.2
	Total:	4.3
300	Periodic Inspection	40.0

TABLE 5. Continued

Calendar Inspections

Calendar Frequency (Months)	Event	Man-Hours to Perform
6	Inspect fire extinguisher	0.1
12	(1) Inspect first aid kit	0.1
	(2) Replace seat belt and shoulder harness	1.5
	Total:	1.6
24	(1) Replace crew seat bottom cover	1.0
	(2) Remove and test altimeters	1.5
	Total:	2.5

11.0 MISSIONS

Representative mission scenarios (Numbers 4 through 9) simulating the designed usage of the OH-58A, within the framework of various combat threats, were developed by COBRO. These missions, along with mission scenarios 0 through 3, required by the ARMS model, are defined in detail in the following pages. The mission completed block indicates that the mission tactical task has been completed at this point in the mission. Total Mission Time includes all ground, flight, combat, and off-site segments.

MISSION 0 - TEST FLIGHT MISSION

The test flight is a noncombat mission and is performed to completely check out the flight characteristics, control response, and instrument performance of the OH-58A after it has been restored to operational condition following major maintenance.

Mission Segment Title	Time in Segment (Min)	Type of Segment
Preflight	10	Ground
Startup	5	Flight
Ground Run	2	Flight
Takeoff	1	Flight
Hover	2	Flight
Climb	2	Flight
Cruise	3	Flight
Autorotate	1	Flight
Setdown	1	Flight
Ground Run	2	Flight
Shutdown	5	Flight
Mission Completed		
Postflight	10	Ground
Refuel	5	Ground

Total Flight Time = 24 min
Total Mission Time = 49 min

MISSION NUMBER 1. REPAIR MISSION

The repair mission is required by the current version of the ARMS model as one of the three internally called missions. Its inclusion in the model simulates the airlift operation of a repair crew to a downed OH-58A. The repair crew restores the OH-58A to an operational status, and both aircraft would then return to the maintenance base. This mission will be flown by Configuration A aircraft only, and will not include combat threats.

Mission Segment Title	Time in Segment (Min)	Type of Segment
Preflight	10	Ground
Startup	5	Flight
Takeoff	2	Flight
Cruise	20	Flight
Setdown	2	Flight
Shutdown	5	Flight
Repair	Actual Mean Time To Repair (MTTR)	Offsite
Startup	5	Flight
Takeoff	2	Flight
Cruise	20	Flight
Mission Completed		
Setdown	2	Flight
Shutdown	5	Flight
Postflight	10	Ground
Refuel	5	Ground

Total Flight Time = 68 min
Total Mission Time = 93 min + MTTR

MISSION NUMBER 2. AIR-EVAC MISSION

The current version of the ARMS model requires the air-evac mission as an internally called mission. This mission simulates the employment of an aircraft to airlift a damaged helicopter from the crash site to a repair facility. Although the OH-58A cannot be used to perform this type of mission, the ARMS model in its present state does require this mission to be defined. Therefore, instead of a detailed mission breakout by segment, a time for which the OH-58A is unavailable to perform other missions is presented. Configuration A aircraft will be used and it is assumed that no combat threats will occur.

Mission Segment Title	Time in Segment (Min)	Type of Segment
Preflight	10	Ground
Air-Evac	90	Flight
Air-Evac Preparation	30	Offsite
Mission Completed		
Postflight	10	Ground
Refuel	5	Ground

Total Flight Time = 90 min
Total Mission Time = 145 min

MISSION NUMBER 3. RESCUE MISSION

The rescue mission is the third internally called mission required by the ARMS model. This mission simulates the recovery operation of the crew and passengers of an aircraft that has been totally lost. It will be flown by Configuration B aircraft only, but no combat will be included.

Mission Segment Title	Time in Segment (Min)	Type of Segment
Preflight	10	Ground
Startup	5	Flight
Takeoff	2	Flight
Cruise	20	Flight
Setdown	2	Flight
Ground run	5	Flight
Takeoff	2	Flight
Cruise	20	Flight
Mission Completed		
Setdown	2	Flight
Shutdown	5	Flight
Postflight	10	Ground
Refuel	5	Ground

Total Flight Time = 63 min
Total Mission Time = 88 min

MISSION 4. COMMAND AND CONTROL (NO COMBAT)

The command and control mission enables the ground unit commander and selected members of his staff to make their own aerial observation upon which to base tactics for an impending operation. This mission is usually conducted at high altitudes (approximately 5000 ft) where the aircraft are continuously circling over the combat area. This mission requires two Configuration A aircraft. No combat is simulated.

Mission Segment Title	Time in Segment (Min)	Type of Segment
Preflight	10	Ground
Startup	5	Flight
Takeoff	2	Flight
Climb	4	Flight
Cruise	10	Flight
Circle	50	Flight
Cruise	10	Flight
Circle	50	Flight
Cruise	20	Flight
Mission Complete		
Setdown	2	Flight
Shutdown	5	Flight
Postflight	10	Ground
Refuel	5	Ground

Total Flight Time = 158 min
Total Mission Time = 183 min

MISSION 5. AERIAL RECONNAISSANCE (LOW INTENSITY COMBAT)

A reconnaissance mission is characterized by its direction toward more specific target areas without the requirement for continuous or systematic coverage. Visual aerial recon provides a means to rapidly collect intelligence information on enemy dispositions and activities. Because of the type of target involved, the need for greater detail, and the characteristics of the different sensors employed to collect the intelligence information desired, reconnaissance missions generally are flown at lower altitudes. This mission will require three Configuration B aircraft.

Mission Segment Title	Time in Segment (Min)	Type of Segment
Rearm	15	Ground
Preflight	10	Ground
Startup	5	Flight
Takeoff	2	Flight
Cruise	40	Flight
Combat	1	Combat
Cruise	40	Flight
Combat	1	Combat
Mission Completed		
Setdown	2	Flight
Shutdown	5	Flight
Postflight	10	Ground
Refuel	5	Ground

Total Flight Time = 106 min
Total Mission Time = 136 min
Total Combat Time = 2 min

MISSION 6. AERIAL SURVEILLANCE (NO COMBAT)

Aerial surveillance missions provide a systematic watch over the battle area and are characterized by increased flexibility and a greater area of surveillance. A surveillance mission is normally performed by visual observation from higher altitudes so that a large area can be observed. Most aerial surveillance missions are flown on a repetitive basis with individual flights overlapping to insure complete coverage. This mission requires two Configuration A aircraft.

Mission Segment Title	Time in Segment (Min)	Type of Segment
Preflight	10	Ground
Startup	5	Flight
Takeoff	2	Flight
Climb	4	Flight
Cruise	25	Flight
Circle	10	Flight
Cruise	35	Flight
Circle	10	Flight
Cruise	35	Flight
Circle	10	Flight
Cruise	25	Flight
Mission Complete		
Descend	2	Flight
Setdown	2	Flight
Shutdown	5	Flight
Postflight	10	Ground
Refuel	5	Ground

Total Flight Time = 170 min
Total Mission Time = 195 min

MISSION 7. TARGET ACQUISITION (LOW INTENSITY COMBAT)

The acquisition of targets for attack is a major capability of the OH-58A. Teams of scout and attack helicopters are capable of acquiring and engaging targets, and of acquiring targets for engagement by other fires. In this effort, a chemical personnel detector may be mounted in a helicopter and used to detect the presence of enemy personnel in a specific location for destruction by attack helicopters. Also, aerial observers may acquire targets for artillery engagement and remain in the area to adjust fires against those targets. This mission requires three Configuration B aircraft.

Mission Segment Title	Time in Segment (Min)	Type of Segment
Rearm	15	Ground
Preflight	10	Ground
Startup	5	Flight
Takeoff	2	Flight
Cruise	30	Flight
Combat	1	Combat
Climb	4	Flight
Circle	20	Flight
Descend	2	Flight
Cruise	30	Flight
Combat	1	Combat
Climb	4	Flight
Circle	20	Flight
Descend	2	Flight
Cruise	30	Flight
Mission Complete		
Setdown	2	Flight
Shutdown	5	Flight
Postflight	10	Ground
Refuel	5	Ground

Total Flight Time = 163 min
Total Mission Time = 203 min
Total Combat Time = 2 min

MISSION 8. AERIAL RECONNAISSANCE (SURGE ONLY - HIGH INTENSITY COMBAT)

The definition of this mission is the same as that for Mission 5. The mission scenario has been modified to depict surge conditions (high intensity combat) in a wartime environment. This mission will be flown only during the designated surge period by three Configuration B aircraft.

Mission Segment Title	Time in Segment (Min)	Type of Segment
Rearm	15	Ground
Preflight	10	Ground
Startup	5	Flight
Takeoff	2	Flight
Cruise	20	Flight
Combat	2	Combat
Cruise	30	Flight
Combat	2	Combat
Climb	3	Flight
Cruise	5	Flight
Descend	1	Flight
Cruise	35	Flight
Combat	2	Combat
Cruise	40	Flight
Mission Complete		
Setdown	2	Flight
Shutdown	5	Flight
Postflight	10	Ground
Refuel	5	Ground

Total Flight Time = 154 min
Total Mission Time = 194 min
Total Combat Time = 6 min

MISSION 9. TARGET ACQUISITION (SURGE ONLY - HIGH INTENSITY COMBAT)

This mission is the same as Mission 7, but has been modified to reflect a high intensity of the combat environment present during surge conditions. This mission will be flown only during the specified surge period, by three Configuration B aircraft.

Mission Segment Title	Time in Segment (Min)	Type of Segment
Rearm	15	Ground
Preflight	10	Ground
Startup	5	Flight
Takeoff	2	Flight
Cruise	25	Flight
Combat	2	Combat
Climb	4	Flight
Circle	25	Flight
Descend	2	Flight
Cruise	25	Flight
Combat	2	Combat
Cruise	25	Flight
Combat	2	Combat
Climb	4	Flight
Circle	15	Flight
Descend	2	Flight
Cruise	20	Flight
Mission Complete		
Setdown	2	Flight
Shutdown	5	Flight
Postflight	10	Ground
Refuel	5	Ground

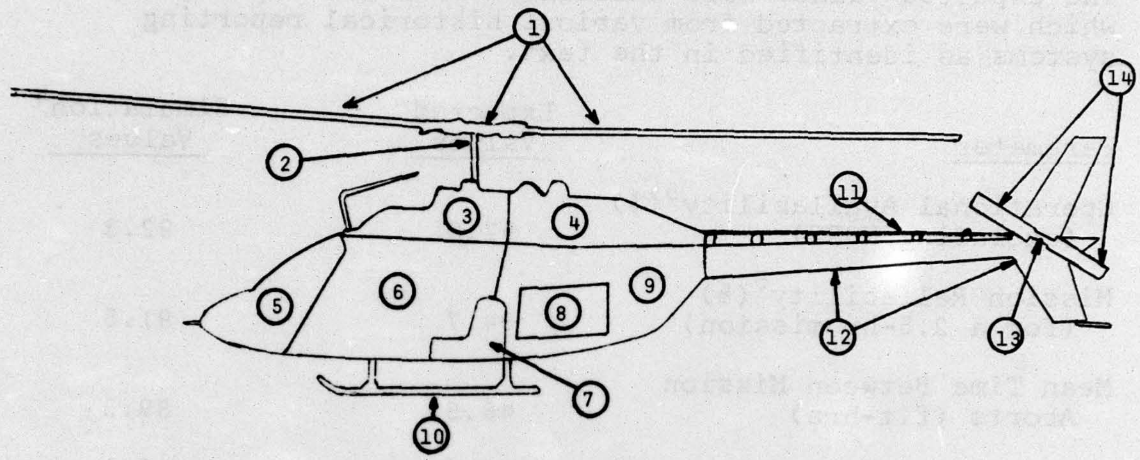
Total Flight Time = 167 min
Total Mission Time = 207 min
Total Combat Time = 6 min

12.0 UTILIZATION

The utilization of the OH-58A was developed to simulate a usage rate of approximately 60 Flight-Hours/Aircraft/Month (FH/AC/MO). During regular operations the aircraft were scheduled to fly at an average rate of 50 FH/AC/MO. But during surge periods, this rate was almost doubled with a scheduled utilization of 95 FH/AC/MO. Since these values represent only the regularly scheduled and random missions, variations in the usage rates will differ from those noted above when flight-hours of internally generated missions are included.

13.0 COMBAT DAMAGE PACKAGE

COBRO developed theoretical combat damage data for the OH-58A. Figure 1 presents an illustration of the combat damage areas. The probability of each area receiving a hit was based upon its percentage of the total aircraft. Assuming a hit was received, the probabilities of the combat consequences were provided based on engineering judgement. The corresponding AVUM repair and remove-and-replace times, in addition to AVIM off-equipment times, were also provided for all combat damage elements. The on-aircraft values were developed through an analysis of the comparison of the AVUM actual lognormal task times of the components within a specific combat area. Again, engineering judgement was used as required to supplement available data. Two empirical distributions were developed to simulate low and high combat threats for the OH-58A. The threats developed do not depict the survivability or vulnerability of the OH-58A, but do simulate the effects of combat on the operational characteristics of the OH-58A. Comparative simulations with various degrees of threat can be performed. The changes in availability, mission reliability, and MMH/FH will be of great significance in evaluating the overall effectiveness of the OH-58A operating in tactical environments.



	Percent of Total		Percent of Total
1. M/R Blades/Hub	6	8. Battery and Avionics	5
2. M/R Mast/Upper Controls	1	9. Aft Fuselage Section	15
3. Transmission and Pylon	6	10. Landing Skid	2
4. Engine Installation	10	11. T/R Driveshaft Installation	3
5. Nose Section	9	12. Tail Boom	17
6. Cabin	21	13. T/R Transmission Hub/Rotating Controls	1
7. Fuel Cell	2	14. T/R Blades	2

FIGURE 1. OH-58A COMBAT DAMAGE AREAS

14.0 OH-58A ARMS VALIDATION RESULTS[3]

The following parameters compare the actual simulation results of the OH-58A ARMS output to expected values. The expected values were calculated from the input data, which were extracted from various historical reporting systems as identified in the text.

Parameter	Expected Values	Simulation[4] Values
Operational Availability[5] (%) (excluding NORS)	97.0	92.3
Mission Reliability[5] (%) (for a 2.5-hr mission)	94.7	91.5
Mean Time Between Mission Aborts (flt-hrs)	45.5	39.3
Usage Rate (FH/AC/MO)	60.0	49.1
Mean Time Between Maintenance Actions (flt-hrs)	3.9	3.8
On-Aircraft AVUM Unscheduled MMH/FH	0.563	0.534
On-Aircraft AVUM Scheduled MMH/FH	0.703	0.661
Mean Time to Repair (MTTR) at AVUM (hrs)	1.4	1.1
Average Crew Size at AVUM	1.5	1.6

[3]The actual results of the OH-58A ARMS analyses used in this comparison did not include combat damage.

[4]Represent the results of a one-month simulation analyses with an automatic stabilization period.

[5]The expected operational availability was based upon the same flight profile used in the simulation. It should be noted that the differences in availability and mission reliability values were due to the fact that the actual values include queuing time for manpower and GSE. Also, missions in the simulation had to meet specified launch windows which are affected by the queuing time for resources. Expected values on the other hand represent "ideal" values and assume no additional downtime waiting for either manpower or GSE.

CONCLUSIONS

As a result of this analysis, a validated ARMS model of the OH-58A is now available. This model will provide the baseline values required to evaluate proposed modifications and conceptual designs of the Army's Light Observation Helicopter series.

The flexibility and degree of detail found in the model provides the Army with a tool for rapid and reliable response to complex RAM, logistics, and survivability/vulnerability-related questions and their impact upon systems effectiveness.

Continuing utilization of simulation techniques in the decision-making process maximizes the experience gained from previous systems. The availability of a complete operational model in the designed environment will have significant impact on predicting life-cycle costs required for operation and maintenance, in order to achieve the major goal of optimum readiness within budget constraints.